Galer, Rose

From: Rose, Jay
Sent: Tuesday, December 18, 2007 9:55 AM
To: Galer, Rose
Subject: FW: paper on LWR targets-- Finck 2007c
Attachments: Minor Actinide Targets in LWRs rev4.doc

From: Phillip J Finck [mailto:Phillip.Finck@inl.gov]
Sent: Monday, October 15, 2007 10:04 PM
To: Rose, Jay
Cc: francis.schwartz@hq.doe.gov; taiwo@anl.gov; Roald Wigeland; buzz.savage@hq.doe.gov
Subject: paper on LWR targets

Here it is; I made minor mods from Temi's latest version

Phillip J. Finck, Associate Laboratory Director
Nuclear Science & Technology
Idaho National Laboratory

Telephone: 208-526-9447
Cell Phone: 208-757-3340
Fax Number: 208-526-2930

Minor Actinide Targets in LWRs

The use of minor actinide (MA) targets in LWRs has been considered under the USDOE AFCI program [1,2]. Generally, the approach is referred to as heterogeneous recycling, in which Pu (or Pu+Np) is contained in the traditional MOX fuel pin (called driver fuel) and the minor actinides (with or without Np) are contained in the target fuel pins. This is different from the homogeneous recycle approach in which all of the transuranics are contained together in the fuel pin, as is being considered in the GNEP approach using fast reactors and also some LWR transmutation strategies.

The potential advantages of the heterogeneous recycle concept include: (1) use of MOX technology similar to existing reprocessing and recycle fuel fabrication processes for early deployment of advanced fuel cycle technology; (2) potential to confine the required remote fabrication of MA-containing targets to a smaller dedicated sub-facility with lower throughput for fabrication; (3) easier fabrication of driver fuel as compared to fabrication of driver fuel containing all of the transuranic elements, with the possibility that the first recycle of Pu or Pu+Np might not need to be done remotely; and (4) enabling options for more flexible management of MA loading in the core. However, at the same time, there are several potential difficulties with the heterogeneous recycle concept related to the confinement of the high radioactivity and heating of the minor actinides. These include: (1) difficulty of recycling, handling, and fabricating target pins/assemblies in the fuel cycle (minor actinide targets would have high heating and radiation levels); (2) immature state of target technology (fabrication, irradiation performance, etc.); and (3) MA storage challenges. It should also be recognized that the targets will have a much higher percentage of the MA in the fuel than would occur with a homogeneous approach, potentially posing more challenging fuel development needs. Consequently, employing targets in LWRs is not a short-term solution, since target technology would have to be developed and its use in commercial reactors will have to be acceptable to the Nuclear Regulatory Commission.

The previous studies performed in the AFCI program concluded that the recycle of americium and curium was technically feasible from reactor physics viewpoint, and that such a recycle approach could result in effective fission and/or transmutation of transuranic materials. Practically, in LWR reactors using targets, the driver and target pins are located in the same assembly. This is due to the necessity to provide neutrons for the irradiation of the predominantly fertile target pins. Separate target assemblies are impractical as it would result in uneven radial core power distribution with assemblies having significantly lower power levels than average. Additionally, the target pins are neutron absorbers and consequently their use results in the increase of the fissile content (higher enrichment uranium fuel or higher plutonium content MOX fuel) to meet specified cycle length and burnup requirements. In this regard, using target pins with MOX pins in an LWR core would require enriched uranium support if multiple recycle of the MOX pin is envisaged.

Strategically, approaches have been considered for complete consumption of transuranics in the target or for stabilization of the material in LWR cores. The former requires a high

neutron flux (hence target pins in the core interior) and long residence time in the core. Ref. 1 indicated that it would take about 25 years to "fission" (i.e., burn) 95% of the initial Am-241 and reaction products in a PWR spectrum (flux level (3 x 10^{14} n/cm^2 sec); 40 years are needed to reach 97% consumption. This long core residence time would necessitate significant R&D for target materials that meet the stringent irradiation performance and safety requirements. (Target materials that have been considered include inert and uranium-base ones, with MA content higher than in traditional MOX fuel pins.) Conversely, the stabilization in the LWR fuel cycle would require multiple-passes of the target material in the core and the attendant difficulties with target handling, recycling, and fabrication in the fuel cycle.

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Considerations have also been given as to what transuranics should be in the target pins. In one option, both Pu and Np could be in the driver MOX fuel and Am could be in the target fuel. In this case Cm (the next highest fraction transuranic) could be stored for tens of years to allow for radioactive decay and its plutonium decay product subsequently mixed with driver fuel. This approach however necessitates the R&D of approaches for separating Am and Cm and for the storage of Cm (which is a high neutron source material). The presence of both Am and Cm in the target leads to the production of higher actinides that are intense producers of spontaneous fission neutrons.

The intermixing of driver and target pins in the same assembly however negates the potential benefit of heterogeneous recycle, which is the confinement of the higher radiotoxic and heating target to a fraction of the reactor core to reduce handling and other dose-related issues. Previous evaluations indicated that a large fraction of the assemblies in the reactor core might be required to contain target pins to successfully use the heterogeneous approach (as much as 30% to 100%). [1] Stabilization of the minor actinide inventory would require a higher fraction (up to 100%) of the core and burn-down a lower fraction. There are also fuel performance issues pertaining to helium production in the target pins that have to be addressed in detailed design and fuel development studies. Consequently, the perceived benefits of using target would have to be properly quantified to justify their utilization.

References

1. M. Salvatores, G. Youinou, R. N. Hill, T. Taiwo, and T. K. Kim, "Systematic Assessment of LWR Recycle Strategies," ANL-AFCI-100, Argonne National Laboratory, (September 2003).

2. Emory D. Collins, Guillermo D. DelCul, John P. Renier, and Barry B. Spencer, "Preliminary Multicycle Transuranic Actinide Partitioning-Transmutation Studies, ORNL/TM-2007/24, Oak Ridge National Laboratory, February 2007.

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